DOCUMENT RESUME

ED 141 153 SE 022 675

TITLE	The Rocky Shore. A Learning Experience for Coastal and Oceanic Awareness Studies, No. 225. [Project COAST].
INSTITUTION	Delaware Univ., Newark. Coll. of Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	74
NOTE	37p.; For related documents, see SE 022 662-687
EDRS PRICE	MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS	Biology; Earth Science; *Ecology; *Instructional Materials; *Marine Biology; *Oceanology; Secondary Education; *Secondary School Science; Teaching Guides
IDENTIFIERS	Coastal Zones; Project COAST

ABSTRACT

This unit is designed to be used by students in biology classes in secondary schools. Emphasized in the unit are coastal life zones, plants and animals that live in these areas, and factors influencing the lives of the organisms. Included in the unit are evaluation materials, instructional objectives, student background information, masters for overhead transparencies, suggested field trip plan and worksheets, a list of supplementary materials, and a selected bibliography. (RH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED141153

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

THE ROCKY SHORE

A Learning Experience for
Coastal and Oceanic
Awareness Studies

Produced by

MARINE ENVIRONMENT CURRICULUM STUDY
MARINE ADVISORY SERVICE
UNIVERSITY OF DELAWARE

and

POPULATION-ENVIRONMENT CURRICULUM STUDY
COLLEGE OF EDUCATION
UNIVERSITY OF DELAWARE

as part of a

PLAN FOR ENVIRONMENTAL EDUCATION

Fall 1974

SE 022 675

Please send evaluations

of learning experiences

to

Dr. Robert W. Stegner, Director

COAST Project

310 Willard Hall Education Building

University of Delaware

Newark, Delaware 19711

Supported in part by

OFFICE OF COASTAL ZONE MANAGEMENT(NOAA)

DELAWARE SEA GRANT COLLEGE PROGRAM(NOAA)

US OFFICE OF EDUCATION

OFFICE OF ENVIRONMENTAL EDUCATION HEW

POPULATION COUNCIL

CORDELIA SCAIFE MAY FOUNDATION

CHRISTIANA FOUNDATION

DEPARTMENT OF PUBLIC INSTRUCTION

DEL MOD SYSTEM

DUPONT EDUCATIONAL AID COMMITTEE

TITLE: THE ROCKY SHORE

* CONCEPT: I.B.3.b.(1)

I. The earth is a finite natural system.

B. All things have arisen from and are dependent upon the natural system of the earth.

3. Most organisms interact in balance with their physical and biotic environment.

b. Ecosystems are dynamic and subject to change.

(1) NATURAL POPULATIONS FLUCTUATE IN RESPONSE TO ENVIRONMENTAL CONDITIONS.

** MARINE CONCEPT: 3.23

3. Marine organisms interact in complex ecosystems.

3.2 Marine organisms are adapted to their environments in different ways.

3.23 POPULATIONS OF MARINE ORGANISMS ARE UNEVENLY DISTRIBUTED.

GRADE LEVEL: 7-10

SUBJECT: Life Science

CLASS PERIODS: Various

AUTHOR: Donofrio

* From A Conceptual Scheme for Population-Environment Studies, 1973. Cost $2.50.

** From Marine Environment Proposed Conceptual Scheme, 1973. No charge.

Both conceptual schemes are available from Robert W. Stegner, Population-Environment Curriculum Study, 310 Willard Hall, University of Delaware, Newark, DE 19711.

INSTRUCTIONAL OBJECTIVES

At the conclusion of this unit the student will be able to:

1. Define the terms supralittoral zone, littoral zone and infralittoral zone.
2. List the conditions to which plants and animals living in supralittoral and littoral zones must adapt in order to survive.
3. Identify plants and animals commonly associated with each zone.
4. Identify, in general terms, the zonation of life on a rocky shore.
5. Describe some of the ways barnacles, mussels, limpets, periwinkles, lichens and kelp have adapted themselves for life at the rocky shore.

INSTRUCTIONS TO TEACHER

1. Duplicate the appropriate number of student background sections. This material has been designed for independent reading but may be reinforced by lecture-discussion techniques. Italicized sentences, which are answers to questions, may be deleted, if desired.
2. Duplicate and administer the pre-test if desired. The pre-test and pictures from resource materials available from the school library may be used to stimulate student interest.
3. Upon conclusion of the field trip and follow-up activities, duplicate and administer the post-test. The post-test included in this lesson should be modified to cover aspects of your own field trip experience. The one included with this learning experience is meant only as an example. Specimens collected on the trip could be used far more effectively than words in the testing process.

THE ROCKY SHORE

I. Student Background Information:

The rocky shore is an extraordinary environment where many forms of life survive and multiply in the turbulence of the continuous pounding of the sea on the rocks. This lesson is a guide for exploring the rocky shore as a unique marine community. Hopefully, as you read, you will learn much about the rocky shore and will be prepared for a field trip, during which you can both use and expand the knowledge you have gained.

All seashores have one feature in common; they are alternately exposed and submerged by the ebb and flow of the tides. The intertidal region, or littoral zone, encompasses all of that area between the height of the extreme high tides and the level of the extreme low tides. The inhabitants of this region are essentially marine, but they are adapted to withstand exposure to the air for varying periods of time.

In the rocky shore environment, as the high tide recedes, the rocks of the littoral zone slowly emerge, exposing the forms of life living on them to the air, wide temperature fluctuations, intense solar radiation, and dessication. Those organisms living on the rocks farthest from the low tide level must withstand this exposure for a greater period of time than those living on the rocks closest to the low tide level. This variation in periods of exposure results in one of the most striking features of the rocky shore--the zonation of life. Regardless of local variations, all rocky shores have three basic zones, characterized by the dominant organisms occupying them. See Figure 1.

The supralittoral zone extends from the extreme limit washed by the spring tides to the upper limits of sea spray. The spray zone is that level above high tide which ocean water regularly reaches by splash or

spray. This zone is sometimes termed the splash zone or black zone. The infralittoral, or sublittoral zone, includes the sea. For this reason, this study will consider only the infralittoral fringe which is uncovered only at spring tide and not even then if wave action is strong.

Between each of the major zones there is a transition zone because the limits of each zone are not precise. As waves lap at the rocks, some cover a few inches and some cover a few feet; wave action is stronger with the incoming tide.

Two generalized illustrations have been provided: Figure 2, Rocky Shore Zones (Mid-Atlantic) and Figure 3, Rocky Shore Zones (North Atlantic). As you examine each zone in more detail, you will want to refer to both of them and note some of the differences in plant and animal life in these two sections of coastline.

JUST ABOVE THE TIDES

Starting at the top of the rocky shore in an area above the highest tide mark you will find either dark grayish lichens or bright orange ones. A lichen represents a close association of an alga and fungus, its cells or filaments being intertwined. The fungus provides the plant body, and the alga the nourishment by means of its capacity for photosynthesis. Lichens are extraordinarily tough plants and are able to withstand extremes of moisture, temperature and wind as well as contact with salt water. The wind and salt air tend to draw moisture from plants causing extreme dryness. Lichens usually colonize the rocks above the water line before any other plant does.

Shrubs growing very near the shore feel the full effects of the elements and tend to be "wind-pruned" and stunted. However, the nearby ocean has beneficial effects also. The ocean water heats slowly in spring and cools slowly in fall and thus acts as a giant thermostat in modifying air temperatures. A slender, hollow, threadlike plant known as sea hair, or Enteromorpha. (Fig. 2, D.) grows here, but it is usually found in the littoral zone as well.

THE SUPRALITTORAL ZONE (The Spray Zone)

What is the spray zone?

That area above the high tide mark where water sprays or splashes regularly.

To what conditions must plants and animals existing in the spray zone adapt?

Small amounts of nutrients and water, harsh winds, temperature extremes, salt spray, dessication.

Name any plants or animals that you think could withstand life here.

Certain algae, lichens, periwinkle (snails), insects, some crustaceans, some worms.

In the spray zone you will find growing a dark band of microscopic blue-green algae, sometimes called black algae. Black lichens may grow here also. Because of all of this dark vegetation the eye sees the spray zone as nearly black in color.

In this region a number of insects are active by daylight. Some, such as springtails, flies and beetles move out of the way if high waves wash over their feeding grounds; others, such as midge larvae, live in tubes cemented against the rock and may occasionally be soaked with splashing sea water or even be completely submerged. At night crabs run across the rocks scavenging for bits of food. Some crustaceans capture living prey such as worms.

The rough periwinkle (Fig. 3, G.) and marsh periwinkle (Fig. 2, F.) move up to the lower levels of the splash zone to feed on the microscopic plants there. Each scrapes the rocks with an organ known as the radula, a continuous belt of tiny, hard, abrasive "teeth."

THE LITTORAL ZONE

Below the black area of the spray zone lies the littoral region, an area covered and uncovered daily by tides. Large numbers of barnacles (Fig. 3, F.) are characteristic of this zone. At low tide their angular white shells form a distinctive belt across the rocky shore. Barnacles are crustaceans, glued to rocks and dependent upon the tides to bring them their food. They feed when immersed, by extending their feathery legs and quickly sweeping them inward, in effect combing the water for microscopic particles. They are cone-shaped with six fitted plates for their sides and with a door of four plates covering their tops. Can you suggest a reason why door plates might be useful to a barnacle?

They close when the tide goes out to protect the animal from dessication.

The bright colored green algae, sea lettuce, Ulva, (Fig. 2, E.) grows fairly high in the littoral zone of the mid-Atlantic shore. It is easily identified by its thin, broad, wrinkled fronds. A slender, hollow, thread-like plant known as sea hair, Enteromorpha, (Fig. 2, D.) grows here, but it may sometimes be found in the lower spray zone.

The dominant seaweeds of the North Atlantic littoral zone are the rockweeds, which are a brown algae. They form a conspicuous yellow-brown band in the mid-littoral zone below the barnacles, sometimes referred to as the Fucoid Zone (Fig. 3). These rockweeds will be mainly of two types. One has flat branches with swollen midribs and small air bladders: the other

has a stringy appearance and sizeable air bladders. See Fig. 4. Air bladders should not be confused with swollen branch tips which are reproductive bodies.

Among the rockweeds is a rock-clinging mollusk able to move freely about, the limpet (Fig. 5.). When the tide comes in, the limpets migrate in search of minute plants for food but will return to an exact resting spot and remain there during the period of low tide.

Unlike their relatives the rough periwinkle and the marsh periwinkle, the common periwinkle (Fig. 3,E.) and the smooth periwinkle (Fig 3., D) are unable to withstand long periods of dryness and confine their grazing activities mainly to the littoral zone. Here they feed largely by rasping away the outer layer of the algal fronds. They move up and down within the zone during the lunar month with the increase and decrease in the maximum height of high tide.

Large dark areas in the littoral zone, especially conspicuous among barnacles, are populations of blue mussels (Fig. 2, B.--also note mussel area on Fig. 3.). The blue-black shells packed closely together may blanket an area. The mussels attach to the rock by means of a web of fine but tough threads called a byssus, which is secreted by the mollusk. Why would mussels need these strong threads?

To prevent the mussel from being torn loose by rough wave action.

Mussels feed by removing minute particles from a current of sea water as it passes through their bodies.

Mussels may grow in association with Irish moss, or Chondrus, (Fig. 3, C.) and other red algae of the Chondrus zone. The true color of Irish moss is a deep burgundy but bleached plants may be yellow and green. In the mid-Atlantic region mussel beds are frequently found in the lower

muddy zone (Fig. 2) growing, again, in association with a red algae.

THE INFRALITTORAL FRINGE

The infralittoral fringe is a busy, active zone. This zone is the most heavily and diversely populated of the rocky shore. The presence of kelp (Fig. 3, B.) makes this zone recognizable. There are many different kinds of kelp, but they are characteristically leathery, brown seaweeds, large (up to several feet at maturity) and firmly anchored by means of a root-like holdfast. The zone is often called the Laminarian zone (Fig. 3) after Laminaria, the genus of the kelp species most abundant here.

Living with the algae low on a rocky shore are a large variety of animals. Sea anemones, tubeworms, bryozoans, mussels, oysters (Fig. 2, C.) can be found attached to the rocks under the seaweeds. Among the mobile animals found here are the spider crabs, hermit crabs, starfish, (Fig. 2, A.) spiny sea urchins, brittle stars, rock crabs (Fig. 3, A.) and small lobsters.

BASIC ZONES ON A ROCKY SHORE

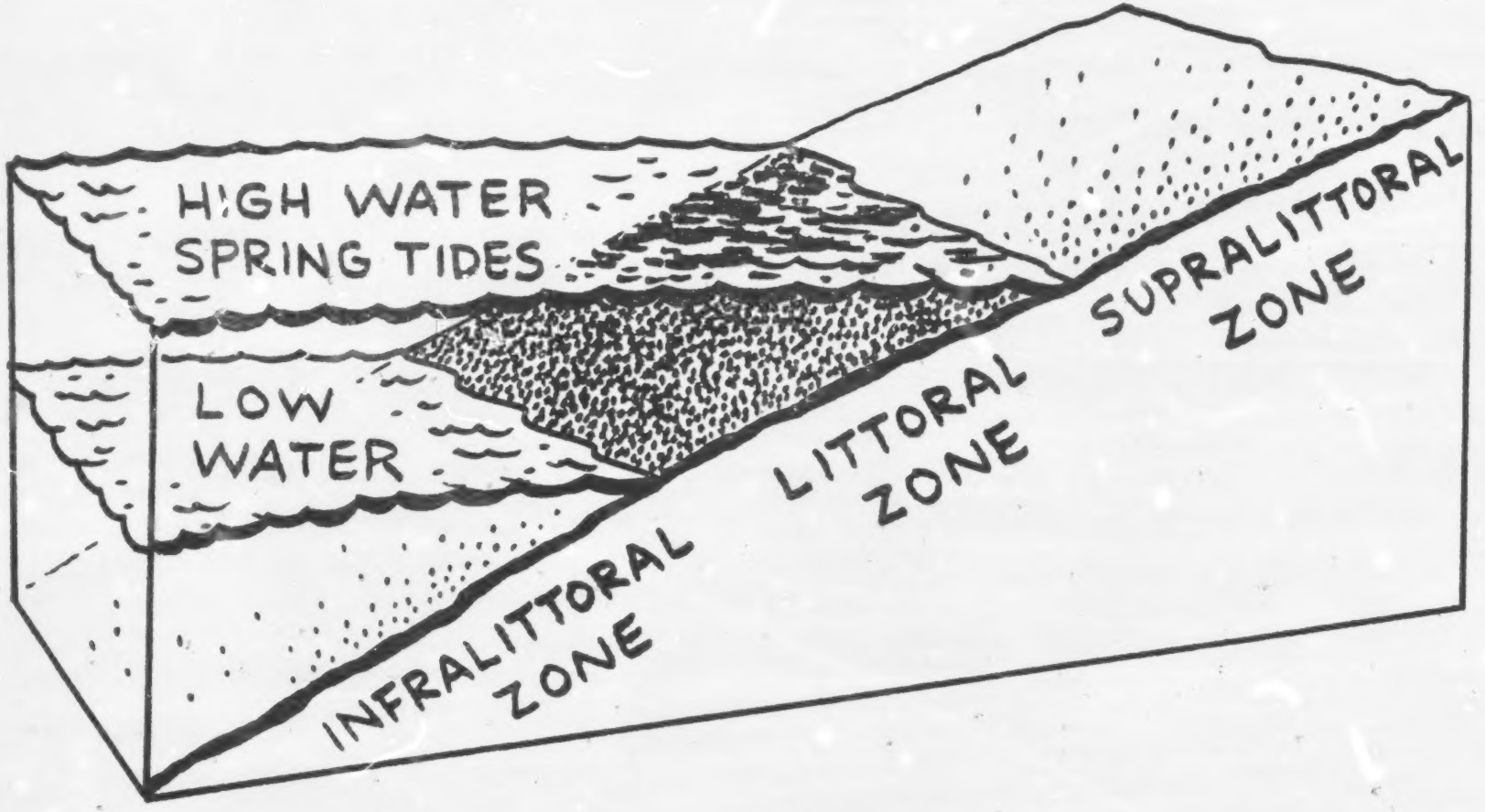


Fig. 1

ROCKY SHORE ZONES

(MID - ATLANTIC)

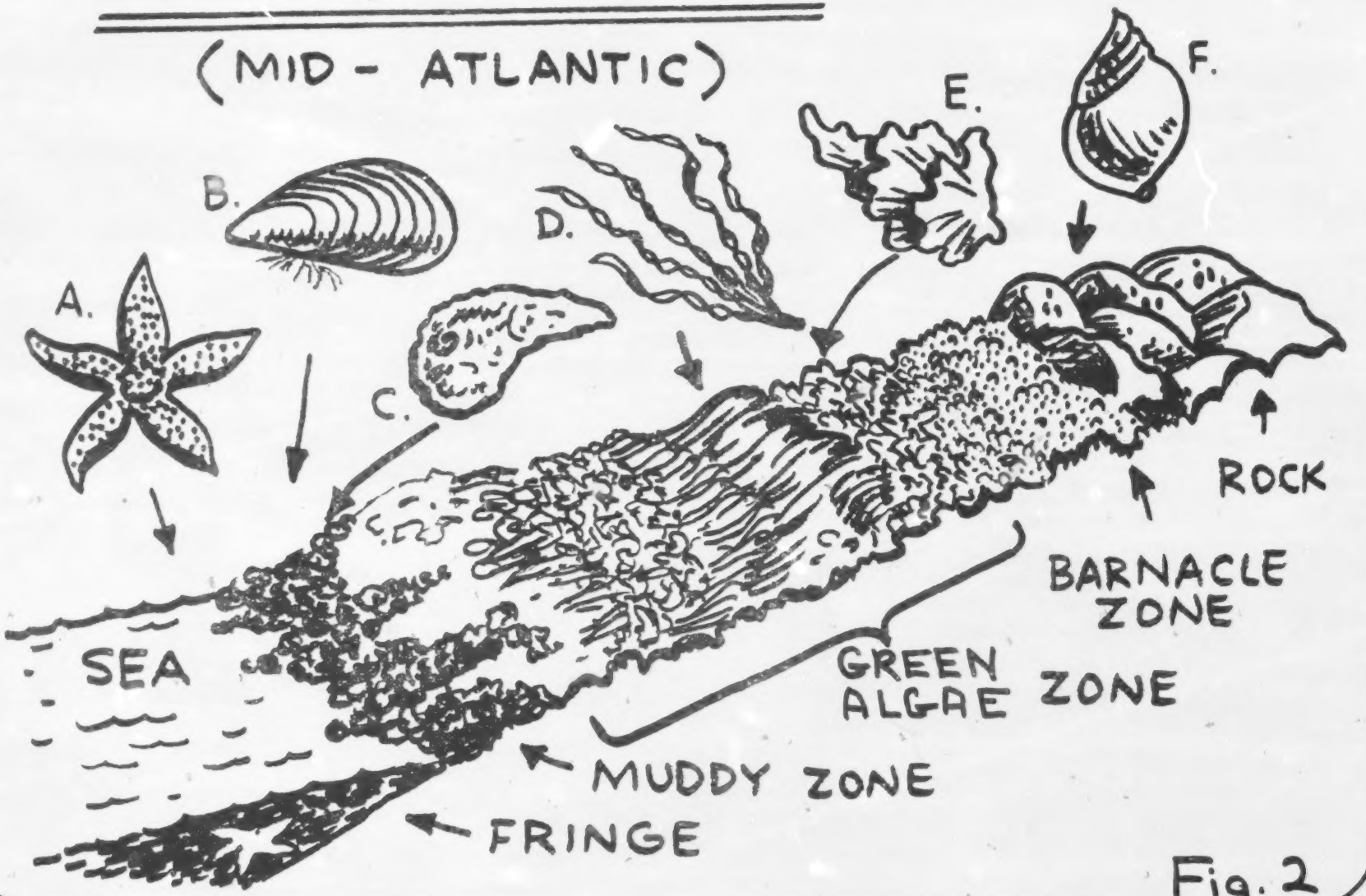


Fig. 2

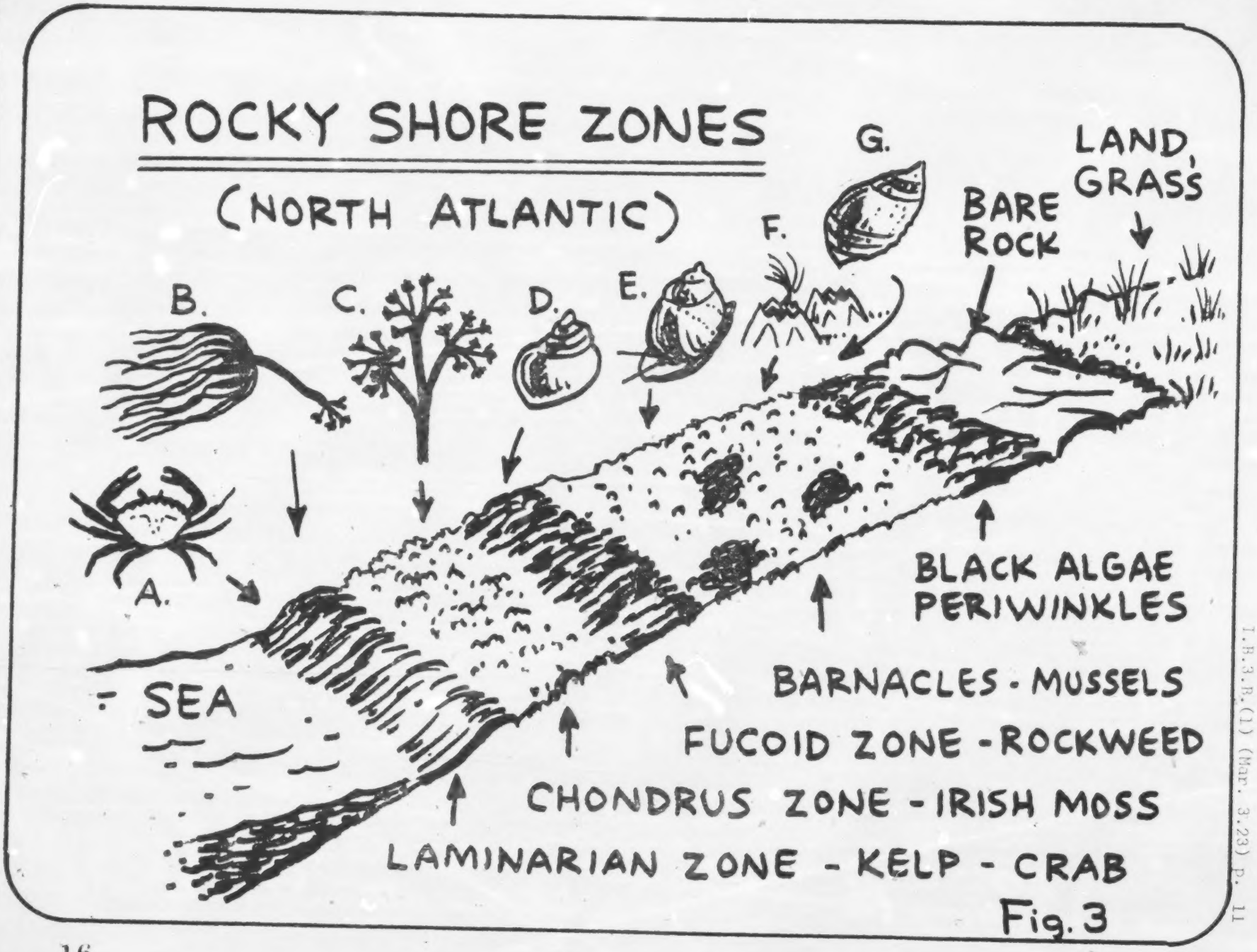
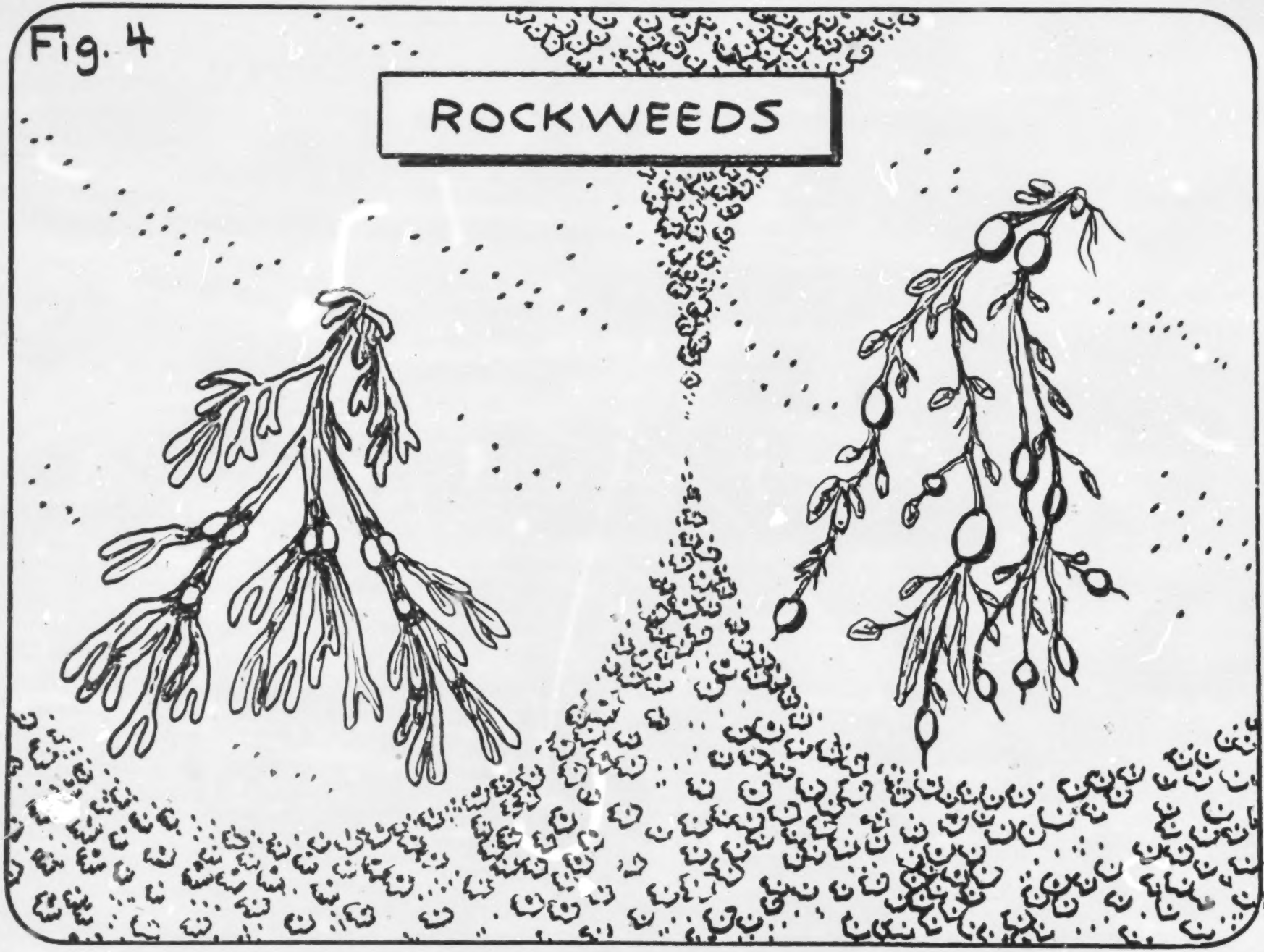


Fig. 3

I.B.3.B.(1) (Mar. 3.23) p. 11

Fig. 4



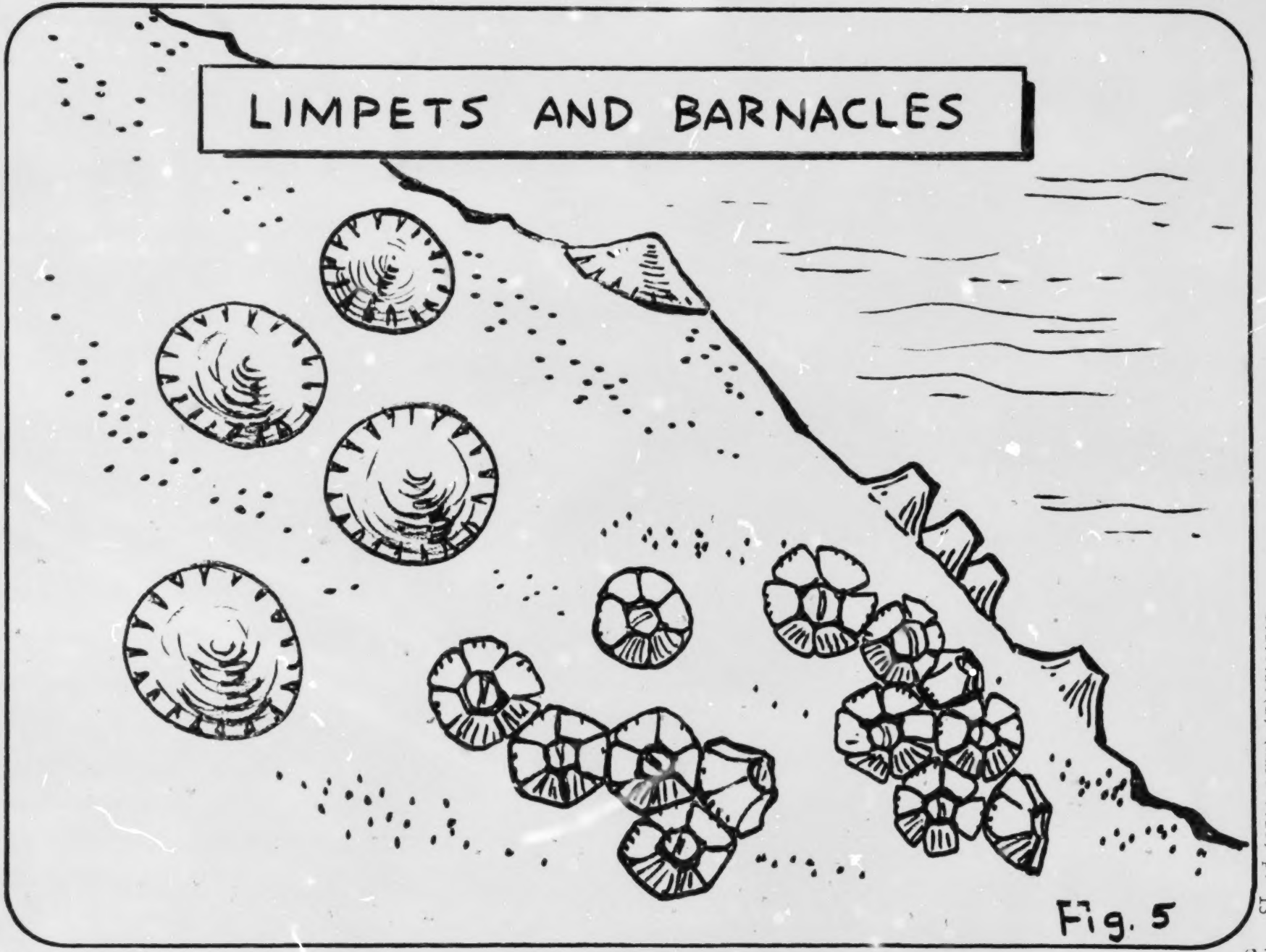


Fig. 5

I.B.3.b.(1) (Mar. 3.23) p. 13

II. The Field Trip

A field trip to a rocky shore would be the ideal way in which to observe some of the features which have been studied and which will be seen in the color slides. If there is no rocky shore in the area, a stone jetty will exhibit similar zonation and be well worth a trip if it can be visited safely.

A. Planning the trip.

1. Make a preliminary survey of the area to be studied. You may wish to adapt the activity to the particular rocky shore or jetty visited.
2. Secure a tide table for the rocky shore you plan to visit. Arrange to be at your destination near low tide.
3. Be sure to take the proper tools and instruct students to wear the proper clothing. Long pants are best since barnacles are very sharp and can easily cause cuts. If you plan to collect any animals, you will need a large container such as a plastic pail. Some animals will have to be pried from rocks with a tool, such as a strong spatula. Boots, wading shoes, or sneakers will be necessary since the rocks can be very slippery.
4. Try to anticipate any hazards you might encounter. Make the students aware of potential dangers in advance of the trip.
5. Duplicate the handouts: field worksheets and questions. (pp. 18-21)
6. Show the 2 x 2" slides. (See Commentary on p. 16)

B. In the Field

1. Choose a rocky portion extending from the low tide mark to the high tide mark. Three zones will be considered--the supralittoral, the littoral and the infralittoral. Review Figure 1.

2. Stretch a string from a point above the splash zone down to a point below the low tide mark. Attach the string to rocks or other objects to keep it taut. The string is used as a reference point for measurements.
3. An area of approximately 3 feet on either side of string should be carefully examined for organisms. Identify as many organisms as you can.
4. Invent a symbol for each kind of algae or invertebrate that you discover. On Field Trip Work Sheet A, map the approximate range of occurrence of each organism.
5. On Field Trip Work Sheet B record the number of individuals in a coat hanger quadrat (the area inside the coat hanger). Quadrats are to be equally spaced along a vertical transect (the string) running from low water to the top of the rocks or jetties.
6. Try to do at least two transects - one in a protected place and one in a location that is more exposed. Be sure to look for any irregularities in what you believe to be the typical zonation picture.
7. Collection is not a necessary part of the trip. However, making a salt-water aquarium consisting of plants and/or animals you have found can be exciting. Be sure you have an all glass aquarium and a supply of seawater. Gather some seashore rocks and gravel for your tank. Take special precautions with animals you remove from their habitats.

Take only small specimens since large ones require so much more oxygen that they may die before you get them home. Put only compatible species in

the same container. Keep your specimens as cool as possible. Ice chests and ice are recommended if specimens are transported any distance or if the specimens are kept in buckets for a long period of time.

In the classroom it is important to have an automatic aeration device for the aquarium. A small inexpensive one will be quite adequate. Mark the initial water level and replace evaporated water with distilled water. Gently scrape the crusty salt accumulation from the sides of the container into the water with a wooden spatula. Feed carnivorous specimens small amounts of frozen food such as brine shrimp. Remove all uneaten food promptly to avoid fouling the tank. Be sure that algae is provided for plant eaters. (See teacher resource packet I.B.3 (Marine 3.22) Marine Aquaria, available from Population-Environment Curriculum Study, 310 Willard Hall, University of Delaware, Newark, DE 19711.)

SUGGESTED COMMENTARY FOR SLIDE PRESENTATION

Slide number:

14. Whether you visit a rocky shore or a stone jetty as shown here, you will be impressed by the splashing waves and sea spray in the air.
15. A close look at the rocks, however, may at first be surprising. You may never have noticed the hundreds of plants and animals that live there. Here you see light green Enteromorpha, or sea hair, white spots as barnacles and Fucus, the brownish rockweed.
16. This slide shows zonation on a New England rocky shore.
17. Shown here is a rock crevice left dry by the tides. The rocks here are hot--it is noon and the tide is low.

18. This is a rock partially submerged. Notice the dense mussel bed and green Ulva, or sea lettuce. Many small animals can be found living under this heavy growth.

19. In this slide try to find two kinds of green algae, Enteromorpha, or sea hair, Ulva, or sea lettuce, Fucus, or rockweed, barnacles, and mussels.

20. This is a more distant view of rocks. Can you locate some of the zones you have read about? Which ones?

Are you ready for a trip to the rocky shore?

FIELD TRIP--What did you see?

While you are exploring keep these questions in mind. The group will discuss the answers after all observations are completed.

(a) Which animals were most abundant in each zone? Discuss reasons for this distribution. _____

_____

(b) In which zone did you find the most animals? How do you account for the larger number in this zone? _____

_____

(c) How do the animals you found differ? Are their differences related to where they live? _____

_____

(d) Study some of the shells, noting their shapes. How would these shells protect the animals against the shock of waves beating against the shore? _____

_____

(e) Did you find mussels bound to rocks by tough threads? How would this arrangement help the mussels at high tide? What other protection do they have from the strong waves? _____

_____

(f) Did you find other animals which are able to anchor themselves in any way? Discuss these. _____

_____

_____

(g) How do the animals get food in each zone? Are some dependent on others? What structures help them obtain food? What structures help protect them against other animals? _____

_____

_____

(h) Is there evidence that some animals feed on plants? What plants do you find that might serve as food for these animals? What would happen to animal life on the beach if there were no plants at all?

_____

_____

_____

(i) Do you find animals that look like plants? What makes you think they are animals? Describe some of these. _____

_____

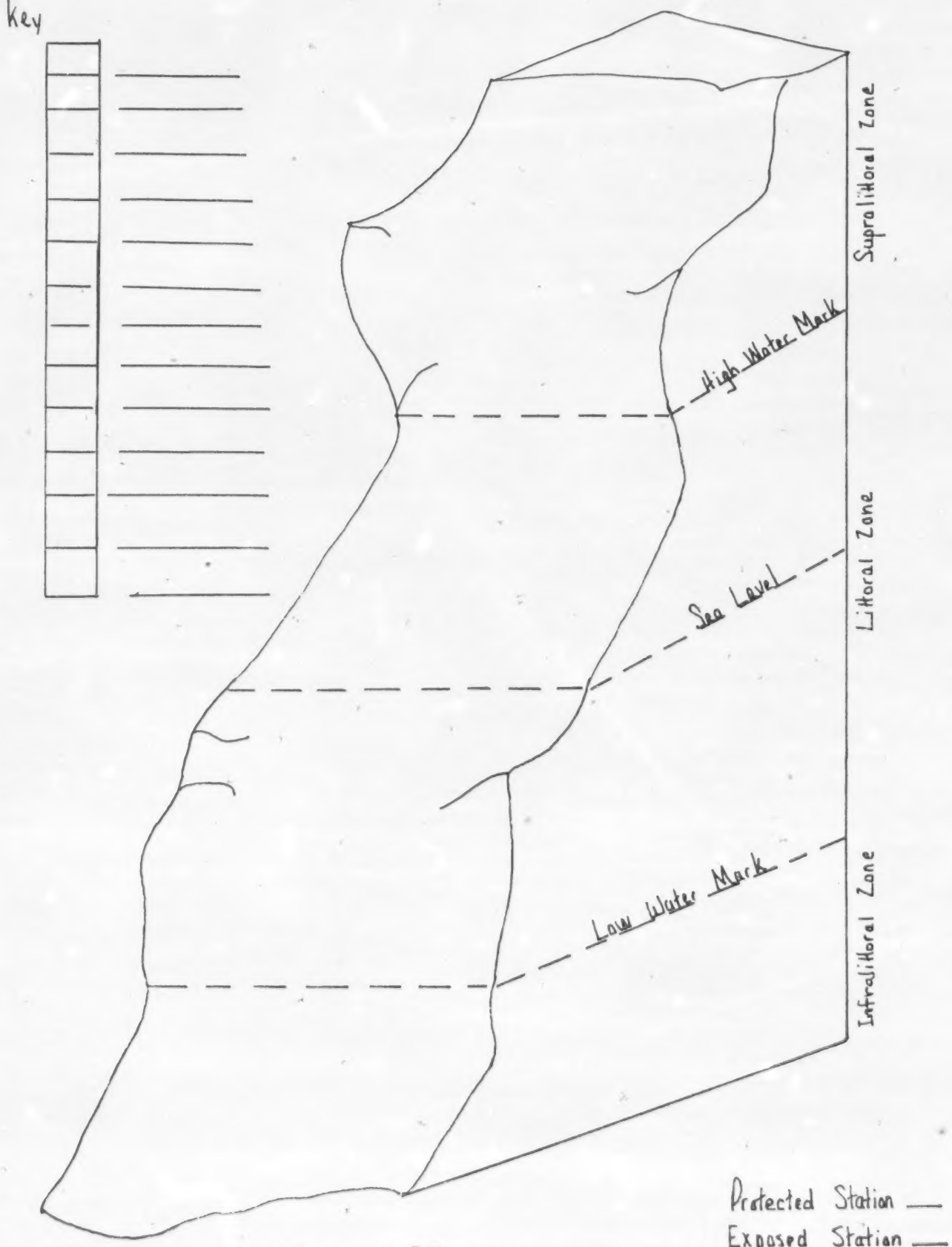
_____

(j) What clues did you find regarding different ways in which animals increase in numbers? _____

_____

_____

Field Trip Work Sheet A



Field Trip Work Sheet B

Name _____

Description of Location _____

Quadrant Number

Water Level _ _ _ _ _ _ _ _ _ → Rock Top

Kind of Plant or Animal	1	2	3	4	5	6	7	8	9	10

Note: Record as percent cover or number of individuals per quadrat frame. Quadrants are to be equally spaced along a vertical transect running from low water to the top of the jetty or rock.

III. Supplementary Activities

1. Maintain a salt water aquarium as discussed in the field trip section, pp. 15-16.
2. The rocky shore can be studied at different seasons of the year to see how the plants and animals living there adapt to the seasonal variations.
3. Additional field trips might include a comparison of areas such as a sandy beach and a rocky shore, or a sandy beach, a rocky shore and a mud flat. Can you observe a zonation of life on a sandy beach or a mud flat? It will be necessary to look more carefully than in the case of the rocky shore.
4. Count the number of mussels in the spring on a predefined rock surface. In early fall return to the same area and count the mussels. What might account for the differences in your count?
5. (For shore areas where limpets are abundant.) If it is possible to remain at the field trip site through two successive low tides, (as on a weekend or overnight field experience) find some way to mark several limpets at low tide, perhaps with different colored dots of waterproof paint or waterproof marking pens. Mark also the resting spot of each. Observe the limpets at the next low tide. Are all marked specimens in the same location as at the previous low tide? Remove a limpet and examine the surface beneath it. Is there any evidence of depression in the surface?
6. Look at Figure 4. How would you explain the bare areas on the rock?

The movement of the rockweeds in response to wave action causes a constant sweeping which, in effect, scours the rock.

7. Look at Figure 5, which shows a group of barnacles as they might appear on a rocky shore. It is known that all of the barnacles here are the same age. Can you account for the differences in size?

Crowding leads to development of a narrow, taller cone of the shell. Barnacle larvae are free-swimmers and are known to check out an area before attaching for life. Can you suggest some reasons why the barnacles are not evenly distributed?

A rough surface is an easier attachment than a smooth one; barnacle larvae do not attach on a slippery film of microscopic algae.

PRE-TEST

Write True or False in front of the following statements.

_____1. The area along a coastline which is alternately covered by water and exposed to air because of the rise and fall of tides is called the littoral zone.

_____2. The splash zone is another name for the supralittoral zone.

_____3. A periwinkle is a small snail.

_____4. Barnacles are green algae found growing on a rocky shore.

_____5. Rockweeds are brown algae with air bladders.

_____6. The infralittoral zone is often dry and exposed to the sun's rays.

_____7. Life along the rocky shore tends to organize into more or less parallel bands of distinctive plant and animal associations.

_____8. Lichens need a large amount of water to grow.

_____9. A limpet is a special type of barnacle.

_____10. One reason barnacles do well along the rocky shore is that they are able to close up when the tide goes out.

POST-TEST

A. Write a definition of the following terms:

1. Supralittoral zone

2. Littoral zone

3. Infralittoral zone

B. Match the plant or animal in the lefthand column with the zone in which it is most likely to be found. Place the correct letter in front of each number.

___1. Sea lettuce (Ulva)

___2. Rockweeds

___3. Blue-green algae

___4. Barnacles

___5. Irish Moss (Chondrus)

___6. Rough periwinkle and marsh periwinkle

___7. Starfish

___8. Limpet

___9. Common periwinkle and smooth periwinkle

___10. Kelp

a. Supralittoral zone

b. Littoral zone

c. Infralittoral zone

C. Name a specific adaptation for life at the rocky shore possessed by each of the following:

1. Barnacles

2. Mussels

3. Lichens

4. Kelp

5. Limpets

6. Periwinkles

D. List conditions, in the spaces indicated below, to which plants and animals must adapt in order to survive in the —

1. Supralittoral zone

   a.

   b.

   c.

   d.

2. Littoral zone

   a.

   b.

E. During your trip to the rocky shore you observed a zonation which at a distance appeared as moderately distinct bands of color. Suggest one plant or animal which could be responsible for each colored zone outlined below. Write your answer next to the color.

Gray-green

Bare rock

Nearly black

White

Green

ANSWERS TO PRE-TEST

1. True
2. True
3. True
4. False
5. True
6. False
7. True
8. False
9. False
10. True

ANSWERS TO POST-TEST

A. 1,2,3. Answers will vary but should include relative position of each zone and its relation to tidal sequence.

B. 1. b
2. b
3. a
4. b
5. b
6. a
7. c
8. b
9. b
10. c

C. Answers will vary here somewhat also.

1. The ability to "comb" the water for microscopic organisms when immersed and to close its door plates when exposed
2. Attach to rock by means of fine, tough threads (byssus)
3. The ability to withstand conditions of extreme dryness.
4. Possess root-like holdfasts for anchoring
5. Ability to move out in search of food when immersed and return to exact resting spot for period of exposure.
6. Varying tolerance to exposure; scrape algae from rocks or outer layer from large fronds by means of radula.

D. 1. Small amounts of nutrients and water

Harsh winds

Temperature extremes

Salt spray

Dessication

2. Wave shock

A period of exposure twice a day, which implies b. c. and e. above.

A period of immersion twice a day.

E. Gray-green: Lichens

Nearly black: Blue-green algae; black lichens

White: Barnacles

Green: Sea lettuce (Ulva); Sea hair (Enteromorpha)

BIBLIOGRAPHY

Amos, William H., 1966, The Life of the Seashore. McGraw-Hill, Inc., New York.

Kingsbury, John M., 1970, The Rocky Shore. The Chatham Press, Old Greenwich.

Lawson, Chester A., and R. E. Paulson, editors., 1958, Laboratory and Field Studies in Biology. Holt, Rinehart and Winston, New York.

Lewis, J. R., 1964, The Ecology of Rocky Shores. English Universities Press.

McConnaughey, Bayard H., 1970, Introduction to Marine Biology. C. V. Mosby Company, St. Louis, Mo.

Moore, Hilary B., 1958, Marine Ecology. John Wiley & Sons, Inc., New York.

Smith, Robert L., 1966, Ecology and Field Biology. Harper-Row, New York.

Southward, A. J., 1966, Life on the Seashore. Harvard University Press, Cambridge, Mass.

Stegner, Robert., 1963, Marine aquaria. The American Biology Teacher. 25(2).